(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 February 2001 (15.02.2001)

PCT

(10) International Publication Number
WO 01/11522 A2

(51) International Patent Classification⁷: G06F 17/60

(21) International Application Number: PCT/US00/21453

(22) International Filing Date: 5 August 2000 (05.08.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/147,456 6 August 1999 (06.08.1999) US

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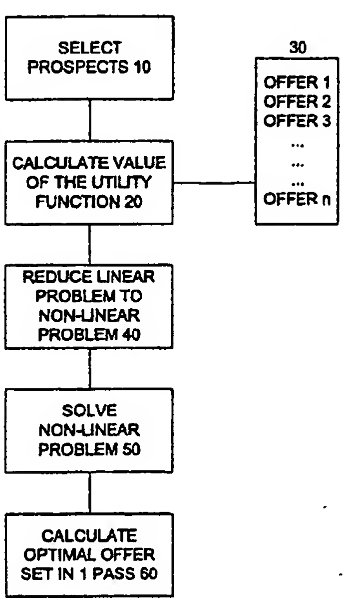
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *Without international search report and to be republished upon receipt of that report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD FOR OPTIMIZING NET PRESENT VALUE OF A CROSS-SELLING MARKETING CAMPAIGN



(57) Abstract: The present invention applies a novel iterative algorithm to the problem of multidimensional optimization by supplying a strict, nonlinear mathematical solution to what has traditionally been treated as a linear multidimensional problem. The process consists of randomly selecting a statistically significant sample of a prospect list, calculating the value of the utility function for each pair of an offer and selected prospects, reducing the original linear multidimensional problem to a non-linear problem with a feasible number of dimensions, solving the non-linear problem for the selected sample numerically with the desired tolerance using an iterative algorithm, and using the results to calculate an optimal set of offers in one pass for the full prospect list.

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TITLE: Method for Optimizing Net Present Value of a Cross-Selling Marketing Campaign

FIELD OF THE INVENTION

This invention relates generally to the development of a method to optimize the effects of cross-selling marketing campaigns. More specifically, this invention is an improvement on the application of classical methods of discrete linear programming to the problem of multidimensional optimization.

BACKGROUND OF THE INVENTION

Businesses typically have a number of promotions to offer to a large list of prospective customers. Each promotion may have an eligibility condition, a response model, and a profitability model associated with it.

Some promotions may be combined into *Peer Groups* (i.e., groups of mutually exclusive offers, such as a credit card with different interest rates). A constraint may be placed on the maximum number of offers that goes to any customer; in addition, there may be business requirements such as minimal number of sales, minimal NPV (Net Present Value) per customer, maximal budget, etc. These requirements may apply to any individual promotion, a peer group, or a campaign as a whole.

The goal of cross-selling marketing optimization is to determine what offers to send to which customers to maximize a utility function of the campaign (total NPV, total number of sales etc.), while satisfying all the business requirements and constraints.

The present state of the art lets marketers process one offer at a time. A response and/or profitability model is applied and customers are rank-ordered based on propensity to respond to the offer. After this ordering, a certain percentage from the top of the list is selected to receive the offer. The same process is applied to all available offers separately.

As a result, the best, most responsive and valuable customers are saturated with offers and the middle segment of the customer list is ignored. The overall efficiency of the

campaign therefore degrades.

Another significant drawback of this approach is the inability to satisfy various real-life constraints and business goals.

Most sophisticated marketers have tried to consolidate models built for different offers. However, these attempts have not been based on any solid scientific method, but rather have utilized an ad hoc approach. Because of this, only the most-simple constraints have been able to be satisfied and the solutions have been sub-optimal with respect to a utility function. In fact, these marketers haven't even been able to estimate how far off they are from the true optimum.

What would therefore be useful is a process that provides a mathematically optimal offer allocation, i.e., one that selects an optimal set of offers for each customer that maximizes the utility function and satisfies all business goals and constraints.

SUMMARY OF THE INVENTION

The present invention represents the application of a novel iterative algorithm to the problem of multidimensional optimization. The present invention supplies a strict, nonlinear mathematical solution to what has traditionally been treated as a linear multidimensional problem.

The problem in its original form is a problem of discrete linear programming. However, due to a huge number of dimensions (in a typical business case $N = O(10^8)$, $M = O(10^2)$), the application of classical methods of discrete linear programming is not feasible.

The process of the present invention consists of randomly selecting a statistically significant sample of a prospect list, calculating the value of the utility function for each pair of an offer and selected prospects, reducing the original *linear* multidimensional problem to a *non-linear* problem with a feasible number of dimensions, solving the non-linear problem for the selected sample numerically with the desired tolerance using an iterative algorithm, and using the results to calculate an optimal set of offers in one pass for the full prospect list.

It is an object of the present invention to increase the efficiency of a cross-selling marketing campaign.

It is an object of the present invention to increase the efficiency of cross-selling campaigns that include a large number of offers.

It is an object of the present invention to provide optimization of cross-selling campaigns wherein groups of offers can be mutually exclusive.

It is an object of the present invention to increase the efficiency of cross-selling campaigns that are targeted to large number of prospective customers.

It is an object of the present invention to increase the efficiency of cross-selling campaigns by selecting an individual, optimal set of offers for each customer.

It is an object of the present invention to constrain of maximum number of offers sent to a customer within cross-selling campaigns.

It is an object of the present invention to satisfy business goals, like minimum number of sales and budget constraints, while optimizing cross-selling campaigns as applied to individual offers, groups of offers or the entire campaign.

It is an object of the present invention to maximize a user-chosen utility function, like total NPV or number of sales, within a cross-selling campaign.

It is an object of the present invention to mathematically maximize the utility function *and* satisfy all constraints within a cross-selling campaign.

It is an object of the present invention to allow interactive changes in goals or constraints of cross-selling campaigns and quickly view the results.

It is an object of the present invention to provide final scoring for cross-selling campaigns in a single pass so as to scalable and efficient enough to process a list of 100 million customers overnight.

It is yet another object of the invention to provide true "one-to-one" marketing in cross-selling campaigns.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a flow chart of the basic process of the present invention.

Figure 2 is a more detailed data flow of a marketing optimization process of the

present invention.

Figure 3 is a flow chart of the single pass process of the present invention.

Figure 4 is a flow chart of the novel iterative algorithm of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention represents the application of a novel iterative algorithm to the problem of multidimensional optimization of cross-selling campaigns by supplying a strict, nonlinear mathematical solution to the traditional linear multidimensional problem desired to be solved when offering a large number of promotions M to a very large set of prospective customers N.

The process of the present invention, as shown in **figure 1**, consists of randomly selecting a statistically significant sample **10** of a prospect list, calculating the value of the utility function **20** for each pair of an offer **30** and selected prospects **10**, reducing the original *linear* multidimensional problem to a *non-linear* problem **40** with a feasible number of dimensions, solving the non-linear problem **50** for the selected sample numerically with the desired tolerance using an iterative algorithm, and using the results to calculate an optimal set of offers **60** in one pass for the full prospect list.

Let $A=(a_{ij})$, be a *solicitation matrix*, where

$a_{ij} = 1$, if offer j goes to a customer i

$= 0$, otherwise;

$R = (r_{ij})$, be a *response matrix*, where

r_{ij} – is a probability for a customer i respond to a promotion j;

$P = (p_{ij})$, be a *profitability matrix*, where

p_{ij} – is a profitability of a customer i, if he/she responds to a promotion j.

Total NPV of the campaign, NPV = NPV(A, R, P), is a linear function of a_{ij}, r_{ij}, p_{ij} and other economic parameters of the campaign.

Eligibility conditions, peer group logic, and maximal number of offers per customer constraint can be expressed by a set of inequalities C_{ik}

$$C_{ik}(A) <= 0, \quad i = 1, 2, \ldots, N, \quad k = 1, 2, \ldots, K$$

where C_i are linear functions, and N is of the order of number of customers in the prospect list, K is number of restrictions. These *customer-level restrictions* are applied for each individual. Economic goals are expressed by a set of inequalities G for each promotion and the whole campaign:

$$G_{j,l}(A, R, P) <= 0, \quad j = 1, 2, \ldots, M, \quad l = 1, 2, \ldots, L_j$$

$$G_{0,l}(A, R, P) <= 0, \qquad l = 1, 2, \ldots, L_0$$

where G_j are linear functions, and M is of the order of number of promotions in the campaign, L_j is total number of restrictions. These *main* restrictions are applied for a promotion or the campaign, and G is a sum over all eligible customers.

It is desired to then find a solicitation matrix A that maximizes NPV(A,*) under the condition that all constraints C and G are satisfied.

The solution presented by the inventors uses the following steps, as shown in **figure 2**. A first step is to create a campaign or project by selecting a set **202** of targeting optimizer (TO) projects from a modeling database **200**. Each TO project contains promotion and offer economics, and eligibility information for a selected pool of prospects. Each TO project includes substitute offer groups **206**, model calibration **204**, and eligibility information that is combined with the prospect input to create an eligibility matrix **214**.

For prospect input, one selects, randomly, a statistically significant sample or testing DCP (derived customer pool) **212** of a prospect list from a customer database **210**. Matrices P and R are then calculated for selected prospects at **224**. The next steps, to reduce the original *linear* multidimensional problem to a *non-linear* problem with a feasible

number of dimensions and solve the non-linear problem for the selected sample numerically with the desired tolerance using a novel iterative algorithm (described below) is done by the optimization engine **240**.

Input data reports **230** record the matrices and offers used. Using this input data, campaign level constraints **242**, and offer level constraints **244**, the optimization engine **240** produces a solicitation matrix **250**. This is used to calculate report data **252** for optimization reports **254** that are tested at **260** to see if the selected constraints **242** and **244** satisfied the desired offer solicitation schema **256**. If satisfied, a final report **260** is generated. If the offer solicitation schema **256** are not satisfied, campaign level constraints **242** and offer level constraints **244** are adjusted to produce another iteration.

The optimization engine **240** calculates the vector of parameters L of the *ANPV (adjusted NPV) functions*

$ANPV_j(L, r_i, p_i)$,

where

$j = 1, 2, \ldots,$ # of promotions;

$r_i = (r_{ij})$ – vector of propensities to respond of a customer i to promotions 1, 2, ...

$p_i = (p_{ij})$ – vector of profitability of a customer i for promotions 1, 2, ...

It then calculates the optimal solicitation matrix **250** in a single pass through the full prospect list. To accomplish that, as shown in **figure 3**:

1. Read the next customer record **31**;
2. Calculate vectors r_i and p_i **32**;
3. Calculate $anpv_i = (ANPV_j(L, r_i, p_i),\ j = 1, 2, \ldots,$ # of promotions) **33**;
4. Based on the values of $anpv_i$ and eligibility conditions, calculate solicitation vector

   $a_i = (a_{ij}, j=1, 2, \ldots, \ldots,$ # of promotions), which defines the optimal set of promotions that goes to a customer i at **34**; and
5. Repeat the previous four steps until the end of the customer list at **35**.

To calculate matrices P and R for selected prospects at **224** and reduce the original *linear* multidimensional problem to a *non-linear* problem with a feasible number of dimensions described above, the present invention needs to solve the high dimensional conditional extremum problem with a large number of restrictions. The present invention uses the Lagrange multiplier technique to take into account *only the main restrictions*. They can be of an equality or inequality type. This low-dimensional nonlinear problem is solved by a gradient type iterative process.

At each iterative step, the optimization of $ANPV_j(L, r_i, p_i)$ under customer-level restrictions (high dimensional linear problem) is made directly, record by record. It is equivalent to the following min-max problem:

$\mathrm{Min}_{j(Lb>0,Lc)}\ \mathrm{Max}_{j(C<=0)}\ ANPV(L, r_i, p_i)$,

where $ANPV(L, r_i, p_i) = ANPV(L, r_i, p_i)_0 + L_b\, G_b(A, R, P) + L_c\, G_c(A, R, P)$

Here, summation over all the inequalities is assumed.

The algorithm, as shown in **figure 4**, consists of following steps:

1. Prepare data **41**.
2. Calculate initial value of the functional and gradients **42**.
3. Set a value for initial algorithm steps **43**; for each Lagrange multiplier, the step should be set equal to the initial value of the functional divided by the square of the gradient.
4. Make a step along the gradient **44**.
5. Update the step **45**, if needed.
6. Calculate new value of the functional **46**, taking customer level restrictions into account.
7. Check convergence **47**.
8. If not converged at **48**, go to step 4.
9. Output the results **49** upon adequate convergence.

It is important to underscore that the above algorithm is *not* a heuristic, but delivers a strict mathematical solution for the multidimensional optimization problem formulated above.

Tests performed by inventors on a variety of real business cases show that the iterative procedure in Step 4 above typically converges with the tolerance of 0.1% in less then 30 iterations. That allows a user to work with the cross-selling optimizer of the present invention interactively and perform real-time analysis of the financial outcome of marketing activities.

A novel feature of the algorithm used by the present invention, the one-pass scoring, enables rollout scoring of a 100M record database overnight.

The present invention operates on a computer system and is used for targeted marketing purposes. Using the present invention in conjunction with a neural network, the present invention provides a user with data indicating the individuals or classes or individuals who are most likely to respond to direct marketing.

We Claim:

1. A method for optimizing a cross-selling marketing campaign, comprising:

randomly selecting a statistically significant sample of a prospect list;

calculating a value of a utility function for each pair of an offer and selected prospects;

reducing an original linear multidimensional problem of optimizing said utility function to a non-linear problem with a feasible number of dimensions;

solving said non-linear problem for the selected sample numerically with a desired tolerance using an iterative algorithm to produce results; and

using said results to calculate an optimal set of offers in one pass for said prospect list.

2. The method for optimizing a cross-selling marketing campaign of claim 1, wherein said utility function is a net present value (NPV).

3. The method for optimizing a cross-selling marketing campaign of claim 2, wherein said NPV is a linear function of at least a solicitation, response, and profitability.

4. The method for optimizing a cross-selling marketing campaign of claim 3, wherein customer level constraints of eligibility conditions, peer group logic, and maximal number of offers per customer can be expressed by a set of inequalities C_{ik}

$C_{ik}(A) <= 0, \quad i = 1, 2, \ldots, N, \quad k = 1, 2, \ldots, K$

where C_i are linear functions, N is of the order of number of customers in the prospect list, and K is number of restrictions.

5. The method for optimizing a cross-selling marketing campaign of claim 4, wherein campaign level constraints of economic goals are expressed by a set of inequalities G for each promotion and the whole campaign:

$G_{j,l}(A, R, P) <= 0, \quad j = 1, 2, \ldots, M, \quad l = 1, 2, \ldots, L_j$

$G_{0,l}(A, R, P) <= 0, \quad l = 1, 2, \ldots, L_0$

where G_j are linear functions, M is of the order of number of promotions in the campaign, L_j is total number of restrictions, and G is a sum over all eligible customers.

6. The method for optimizing a cross-selling marketing campaign of claim 5, wherein said results are a solicitation matrix A that maximizes NPV(A,*) under a condition that all constraints C and G are satisfied.

7. The method for optimizing a cross-selling marketing campaign of claim 6, wherein said solicitation matrix A is determined by letting $A=(a_{ij})$, where

$a_{ij} = 1$, if offer j goes to a customer i

$= 0$, otherwise;

$\mathbf{R} = (r_{ij})$, be a *response matrix*, where

r_{ij} – is a probability for a customer i respond to a promotion j;

$\mathbf{P} = (p_{ij})$, be a *profitability matrix*, where

p_{ij} – is a profitability of a customer i, if he/she responds to a promotion j; and a total NPV of the campaign, NPV = NPV(A, R, P), is a linear function of a_{ij}, r_{ij}, p_{ij}.

8. The method for optimizing a cross-selling marketing campaign of claim 7, wherein an optimization engine calculates the vector of parameters L of the ANPV (adjusted NPV) functions $ANPV_j(L, r_i, p_i)$,

where

j = the number of promotions;

$r_i = (r_{ij})$ – vector of propensities to respond of a customer i to promotions 1, 2, …j;

and $p_i = (p_{ij})$ – vector of profitability of a customer i for promotions 1, 2, …j.

9. The method for optimizing a cross-selling marketing campaign of claim 8, wherein the optimal solicitation matrix is calculated in a single pass through the prospect list by:

reading in customer record i;

calculating vectors r_i and p_i;

calculating $anpv_i$ = $ANPV_j(L, r_i, p_i)$;

using values of $anpv_i$ and eligibility conditions to calculate solicitation vector $a_i = (a_{ij})$, which defines the optimal set of promotions that goes to a customer i; and

repeating the previous four steps until reaching the end of the prospect list.

10. The method for optimizing a cross-selling marketing campaign of claim 9, wherein r_i, p_i are calculated and the linear multi-dimensional problem of optimizing said utility function is reduced to a non-linear problem with a feasible number of dimensions by using a Lagrange multiplier technique to take into account only main restrictions to produce a low-dimensional non-linear problem by a gradient-type iterative process comprising:

making directly, at each iterative step, an optimization of $ANPV_j(L, r_i, p_i)$ under customer-level restrictions equivalent to the following min-max problem:

$\mathrm{Min}_{j\{Lb>0,Lc\}}\ \mathrm{Max}_{j\{C<=0\}}\ ANPV(L, r_i, p_i)$,

where $ANPV(L, r_i, p_i) = ANPV(L, r_i, p_i)_0 + L_b G_b(A, R, P) + L_c G_c(A, R, P)$

and iteratively solving this by:

calculating an initial value of the functional and gradients;

setting a value for initial algorithm steps, wherein for each Lagrange multiplier, the step is set equal to the initial value of the functional divided by the square of the gradient;

making a step along the gradient;

updating the step if needed;

calculating a new value of the functional taking customer level restrictions into account;

checking for convergence;

making another step along the gradient if not converged; and

outputting results upon convergence.

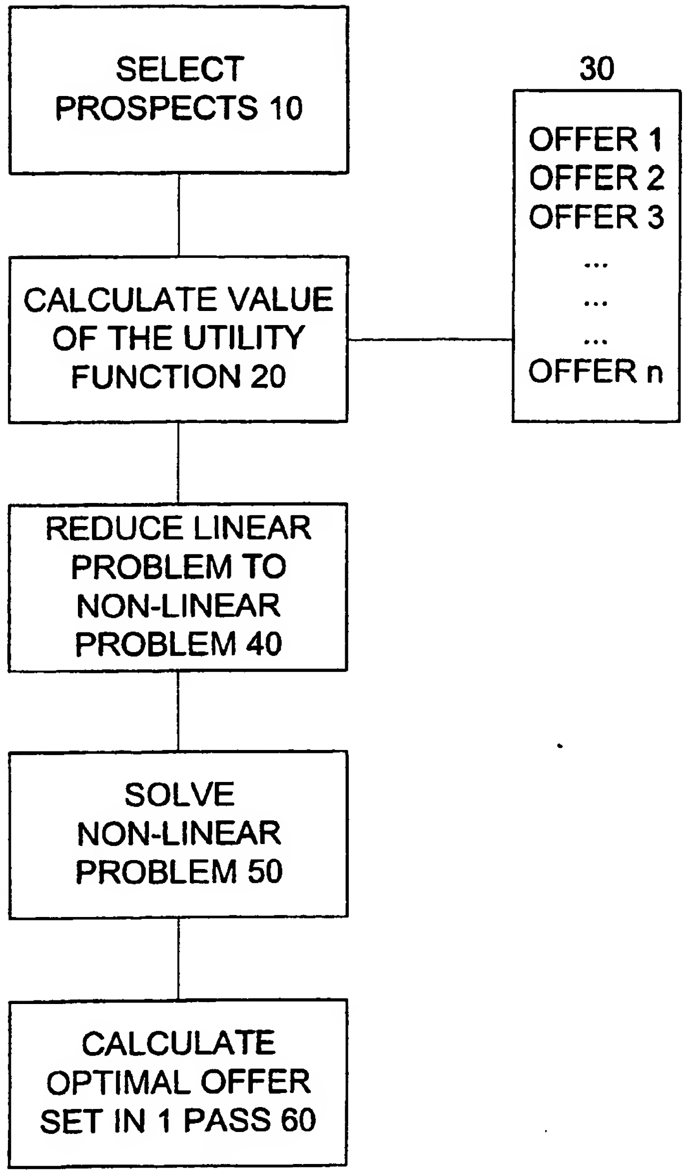
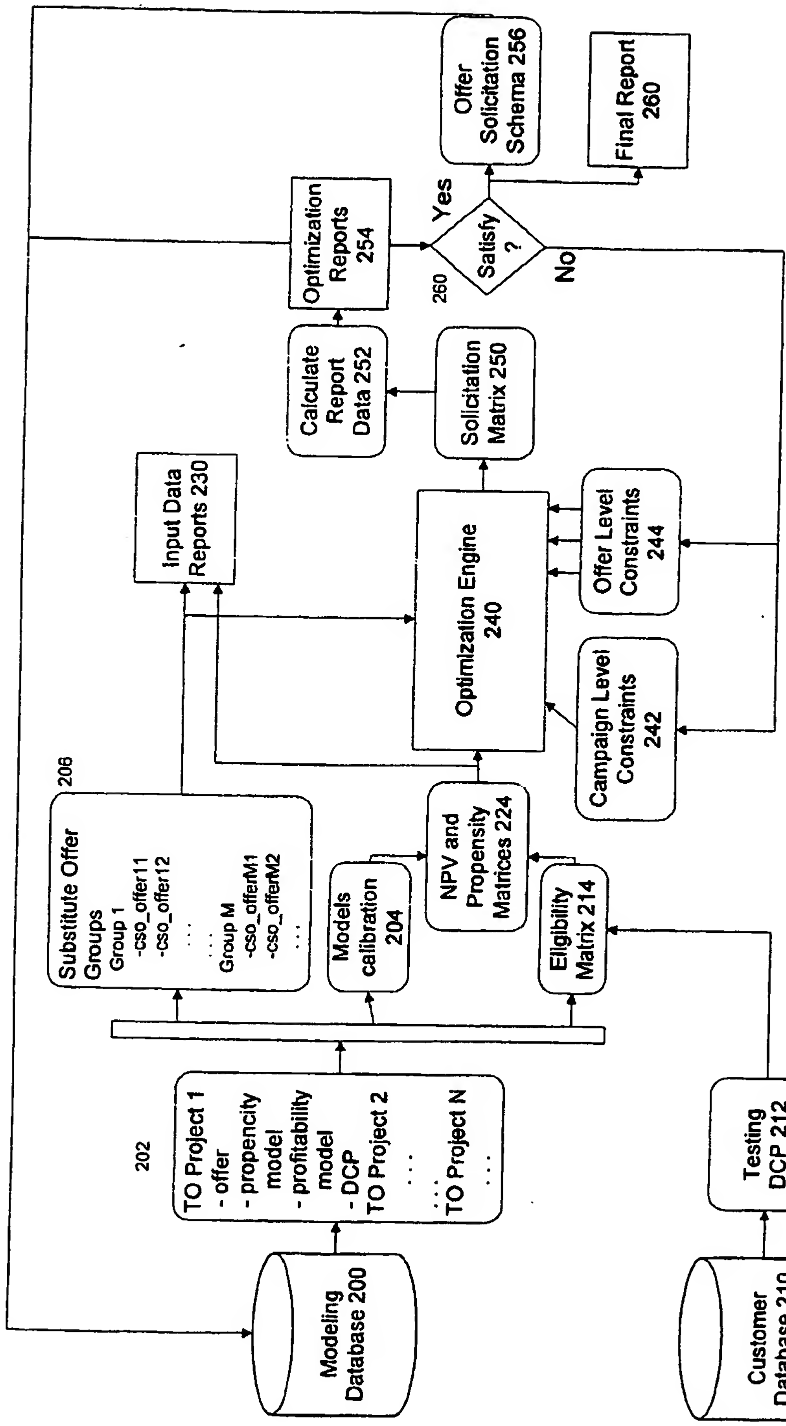

SELECT
PROSPECTS 10
30
OFFER 1
OFFER 2
OFFER 3
...
...
...
OFFER n
CALCULATE VALUE
OF THE UTILITY
FUNCTION 20
REDUCE LINEAR
PROBLEM TO
NON-LINEAR
PROBLEM 40
SOLVE
NON-LINEAR
PROBLEM 50
CALCULATE
OPTIMAL OFFER
SET IN 1 PASS 60

FIGURE 1



Modeling Database 200
202
TO Project 1
- offer
- propencity model
- profitability model
- DCP
TO Project 2
. . .
TO Project N
. . .
Customer Database 210
Testing DCP 212
206
Substitute Offer Groups
Group 1
-cso_offer11
-cso_offer12
. . .
Group M
-cso_offerM1
-cso_offerM2
. . .
Models calibration 204
Eligibility Matrix 214
NPV and Propensity Matrices 224
Input Data Reports 230
Optimization Engine 240
Campaign Level Constraints 242
Offer Level Constraints 244
Solicitation Matrix 250
Calculate Report Data 252
Optimization Reports 254
260
Satisfy ?
Yes
No
Offer Solicitation Schema 256
Final Report 260

Figure 2

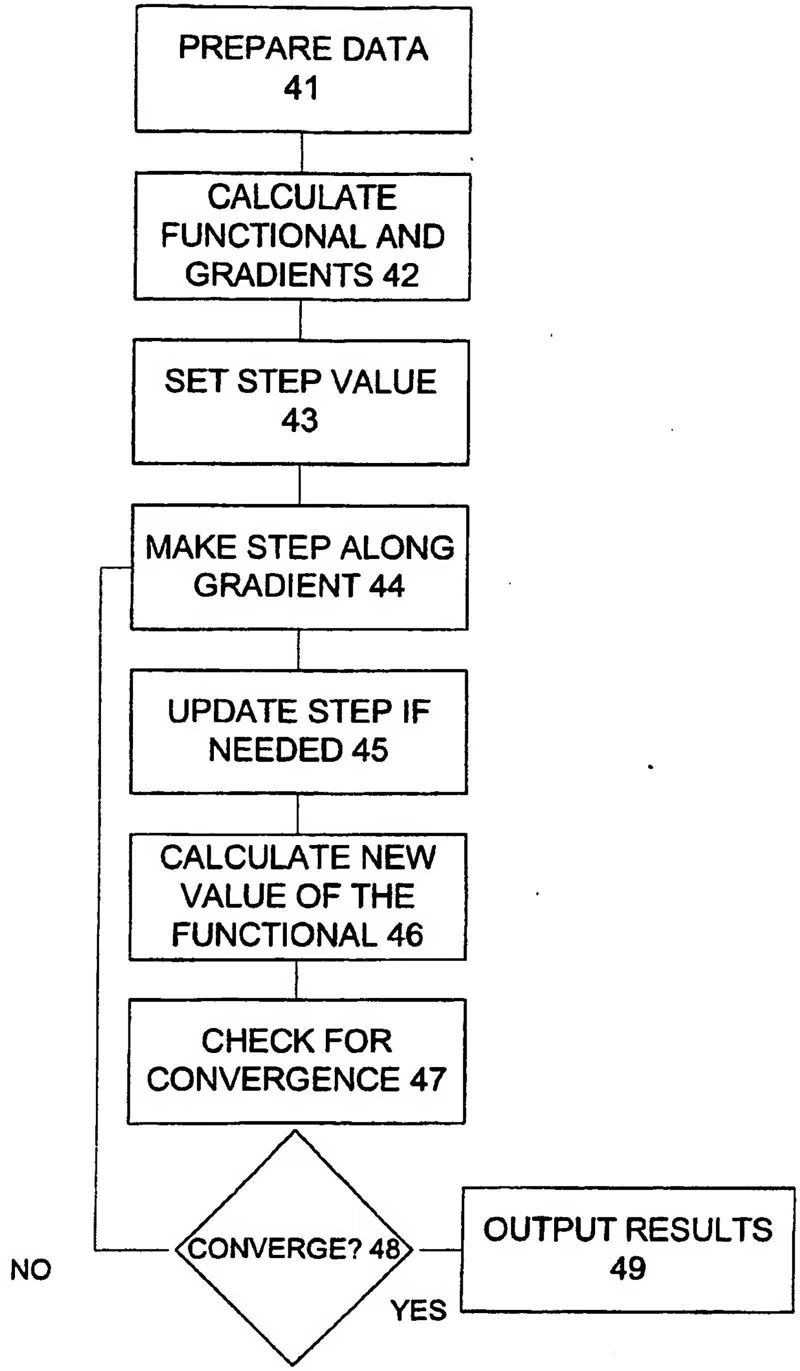

PREPARE DATA
41
CALCULATE FUNCTIONAL AND GRADIENTS 42
SET STEP VALUE
43
MAKE STEP ALONG GRADIENT 44
UPDATE STEP IF NEEDED 45
CALCULATE NEW VALUE OF THE FUNCTIONAL 46
CHECK FOR CONVERGENCE 47
CONVERGE? 48
NO
YES
OUTPUT RESULTS
49

FIGURE 4